

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization  
International Bureau



(43) International Publication Date  
15 March 2001 (15.03.2001)

PCT

(10) International Publication Number  
**WO 01/18517 A1**

(51) International Patent Classification<sup>7</sup>: **G01L 19/08,**  
19/12, 17/00, 7/08

OLX (GB). WILLIAMS, John, Warren [GB/GB]; DERA  
Malvern LW2, St. Andrews Road, Malvern, Worcester  
WR14 3PS (GB).

(21) International Application Number: PCT/GB00/03072

(74) Agent: BOWDERY, A., O.: D/IPD, DERA Formalities,  
A4 Building, Ively Road, Farnborough, Hampshire GU14  
0LX (GB).

(22) International Filing Date: 9 August 2000 (09.08.2000)

(81) Designated States (*national*): AE, AL, AM, AT, AU, AZ,  
BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE,  
DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID,  
IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT,  
LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ,  
PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT,  
TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(25) Filing Language: English

(84) Designated States (*regional*): ARIPO patent (GH, GM,  
KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian  
patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European  
patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE,  
IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG,  
CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

(26) Publication Language: English

Published:

— With international search report.

(30) Priority Data:  
9920885.2 6 September 1999 (06.09.1999) GB

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(71) Applicant (*for all designated States except US*): THE SECRETARY OF STATE FOR DEFENCE [GB/GB]; Defence Evaluation Research Agency, A4 Building, Ively Road, Farnborough, Hampshire GU14 0LX (GB).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): TREEN, Andrew, Shaun [GB/GB]; DERA Farnborough, A7 Building, Room 1146, Ively Road, Farnborough, Hampshire GU14 0LX (GB). LAWRENCE, Chris, Robert [GB/GB]; DERA Farnborough, A7 Building, Room 1146, Ively Road, Farnborough, Hampshire GU14 0LX (GB). SWAN, Martin [GB/GB]; DERA Farnborough, A7 Building, Room GO69, Ively Road, Farnborough, Hampshire GU14

WO 01/18517 A1

(54) Title: PRESSURE INDICATOR

(57) Abstract: A pressure indicator and a corresponding method are disclosed, the pressure indicator comprising a display diaphragm, optionally transparent, and an indicator diaphragm coupled to and in fluid communication with the display diaphragm. In use, pressure is applied to the diaphragms, which may be amplified, whereby a change in the pressure applied causes relative movement between the diaphragms which is observable either on the outer surface of the display diaphragm or through the display diaphragm. The diaphragms may form a compartment preferably containing a liquid or gel. The indicator diaphragm may bear a recognisable configuration or pattern which can be coloured and may comprise a symbol or graphic projecting from its surface. The configuration or pattern may comprise at least two components, each component corresponding to a different pressure. Also disclosed is an inflatable device, especially a football or a tyre, comprising such a pressure indicator.

## PRESSURE INDICATOR

This invention relates to a pressure indicator.

According to a first aspect of the present invention, a pressure indicator comprises a display diaphragm and an indicator diaphragm coupled to and in fluid communication with the display diaphragm and forming a compartment with the display diaphragm; wherein, in use, a change in pressure applied to the diaphragms causes relative movement between the diaphragms which is observable either on the outer surface of the display diaphragm or through the display diaphragm. To see through the display diaphragm effectively, it is preferably transparent.

5 10 15 20 25 30

Preferably, a means to amplify the movement between the diaphragms caused by the change in pressure applied to the diaphragms is provided. This would enable small changes in applied pressure to be observable. The means to amplify the movement between the diaphragms may comprise an article having a first surface and a second surface, the second surface having a larger cross sectional area than the first surface, the first surface being in fluid communication with one of the diaphragms. A change in pressure applied to the second surface causes an amplified movement of the first surface which is communicated to the diaphragms. Preferably, the first surface of the article is the indicator diaphragm.

Preferably, the means to amplify the change in pressure applied to the diaphragms is biased so that on removal of the change in pressure applied, the means to amplify the change in pressure returns to its original position i.e. that prior to the application of the pressure. This ensures that an accurate indication of the pressure is obtained. The biasing means may be a spring or elastomeric material.

In a preferred embodiment, the diaphragms form a compartment and contain a liquid or gel which may be at least partially opaque. The compartment may be sealed, alternatively the diaphragms may be in mechanical communication without being sealed.

In another preferred embodiment, the indicator diaphragm bears a recognisable configuration or pattern such that the configuration or pattern is observable either on the outer surface of the display diaphragm or through the display diaphragm thereby

aiding observation of the relative movement. The recognisable configuration or pattern may comprise a symbol or graphic projecting from the surface of the indicator diaphragm. This facilitates observation on the outer surface of the display diaphragm if the symbol or graphic either abuts the inner surface of the display diaphragm or

- 5 protrudes through the display diaphragm.

Alternatively, either the display diaphragm or, if present, the liquid or gel may be partially opaque. Upon relative movement between the diaphragms, the symbol or graphic which projects from the surface of the indicator diaphragm either appears or disappears or, alternatively, becomes more or less visible when viewed through the

- 10 display diaphragm.

In order to indicate a range of pressure, it is necessary to define the two extremes of that range, i.e. a high pressure extreme and a low pressure extreme. Thus, it is preferable that the configuration or pattern comprises at least two components, each component corresponding to a different pressure.

- 15 Such components may project from the surface of the indicator diaphragm by different amounts, thereby abutting the display diaphragm at different pressures. Alternatively, the components may have different visibility such that they can become visible and invisible at different pressures, e.g. by having different colours or symbols and patterns.
- 20 The relative movement of the diaphragms may be accommodated where either diaphragm comprises a flexible polymer and especially an elastomer. The symbol or graphic may also comprise a flexible polymer or elastomer.

Where the indicator diaphragm is subjected to a higher pressure than the display diaphragm, it is preferable that the indicator diaphragm is impermeable so as to

- 25 prevent leakage.

According to a second aspect of the present invention, apparatus comprises a fluid reservoir and a pressure indicator according to any preceding claim wherein one of the diaphragms is in fluid communication with the fluid reservoir. The apparatus may be an inflatable such as a tyre or a ball.

The pressure indicator may be incorporated in the surface of the fluid reservoir or, more conveniently housed in or around a valve assembly.

According to a third aspect of the present invention, a method of indicating either fluidic or mechanical pressure comprises the steps of applying a pressure to a

5      pressure indicator, the indicator comprising a display diaphragm and an indicator diaphragm coupled to and in fluid communication with the display diaphragm; and observing the relative movement between the diaphragms caused by the pressure applied, either on the outer surface of the display diaphragm or through the display diaphragm.

10     Preferably, the indicator diaphragm bears a recognisable configuration or pattern such that the relative movement is observed either when the pattern or configuration abuts the display diaphragm, or when the pattern or configuration becomes visible through the display diaphragm.

In a preferred method, the pattern or configuration may comprise a symbol or graphic

15     having at least two components where each component corresponding to a different pressure. This enables a pressure range to be defined whereby one of the components defines a lower relative pressure, the other a higher relative pressure.

The invention will now be described, by way of example only, with reference to the figures in which:

20     Figure 1 shows, schematically, a football having a pressure indicator according to the present invention;

          Figure 2a shows a cross-section of the pressure indicator of figure 1 when the football is under inflated;

25     Figure 2b shows the indication visible on the pressure indicator of figure 1 when the football is under inflated;

          Figure 2c shows a cross-section of the pressure indicator of figure 1 when the football is correctly inflated;

          Figure 2d shows the indication visible on the pressure indicator of figure 1 when the football is correctly inflated;

Figure 2e shows a cross-section of the pressure indicator of figure 1 when the football is over inflated;

Figure 2f shows the indication visible on the pressure indicator of figure 1 when the football is over inflated; and

5 Figures 3a and 3b show, schematically, a valve having a pressure indicator according to the present invention.

Figure 3c shows a valve assembly suitable for use in a valve described in Figures 3a and 3b.

10 Figures 4a and 4b show a display diaphragm according to the present invention.

Figure 4c shows an indicator diaphragm according to the present invention.

Figure 5 shows a pressure indicator according to the present invention.

Figure 6 shows a pressure indicator according to the present invention.

Figure 7 shows a pressure indicator according to the present invention.

15 Figure 8 shows a means to amplify the applied pressure according to the present invention.

Figure 1 shows, schematically, a football 1 having a pressure indicator 2 according to the present invention. A valve 3 is positioned in the wall of the football, whereby, using conventional methods, the football can be inflated through the valve, e.g. by

20 using a pump (not shown). The pressure indicator is exposed to both the internal pressure of the football and atmospheric pressure outside the football. It will be appreciated that there is an optimal range in which a football should be pressurised for bounce and control. Below this range, the football can be said to be under inflated and above, it can be said to be over inflated.

25 Figure 2a shows a cross-section of the pressure indicator 2 when the football 1 is under inflated. The pressure indicator comprises a transparent display diaphragm 4 coupled to and in fluid communication with an indicator diaphragm 5. The diaphragms form a compartment 6. The surface of the indicator diaphragm has projecting therefrom a diamond symbol 7 and a cross symbol 8 where the diamond symbol

30 projects further from the indicator diaphragm than the cross symbol. An opaque gel

fills the remainder of the compartment. An example of a suitable gel is a silicone rubber although a person skilled in the art will be aware of other suitable materials.

Figure 2b (not to scale) shows the indication visible through the display diaphragm 4 of the pressure indicator 2 when the football 1 is under inflated. When under inflated,

5 neither the diamond 7 or the cross 8 are visible though the display diaphragm 4 due to the opaqueness of the gel contained in the compartment i.e. they do not contact the indicator diaphragm.

Figure 2c shows a cross-section of the pressure indicator 2 when the football 1 is correctly inflated. Pressure is exerted on the indicator diaphragm 5 which is sufficient

10 to cause the indicator diaphragm to depress, thereby allowing the diamond 7 (but not the cross 8) to abut the display diaphragm 4. When the diamond abuts the display diaphragm, the opaque gel is displaced such that the diamond becomes visible when viewed through the display diaphragm as shown in figure 2d (not to scale).

Figure 2e shows a cross-section of the pressure indicator of figure 1 when the

15 football 1 is over inflated. The pressure exerted on the indicator diaphragm is greater than that as shown in figure 2c resulting in greater relative movement between the diaphragms. As such, both the diamond and the cross abut the display diaphragm and thus become visible when viewed through the display diaphragm as shown in figure 2f (not to scale).

20 Figure 3a shows, schematically, a valve 9 having a pressure indicator 10 according to the present invention. In use, the valve is connected to an inflatable or inflated object 11. The indicator assembly 12 is positioned within the transparent valve casing 13 so as to be visible when viewed from above. The indicator assembly may also be viewed from the side. The pressure indicator is exposed to atmospheric pressure

25 and also the internal pressure of the object via the pressure equalisation channel 14.

The indicator assembly comprises a display diaphragm 122 which is responsive to changes in pressure via the pressure equalisation channel 14. The display diaphragm 122, on an increase in pressure, presses against the indicator diaphragm 121. The indicator diaphragm 121 may be made from a lenticular material such as is

30 described in figure 4. When the correct pressure is communicated to the display

diaphragm 122 via the pressure equalisation channel 14, the display is revealed. The display diaphragm 122 is annular in shape.

Figure 3b shows, schematically, a valve 15 having a pressure indicator 16 according to the present invention. In use, the valve is connected to an inflatable or inflated object 17. The indicator assembly 18 is positioned within the transparent valve casing 19 which acts as a guide to light entering the casing so the indication is visible when viewed from above. The indicator assembly may also be viewed from the side. The pressure indicator is exposed to both the internal pressure of the object and atmospheric pressure.

Figure 4a shows a display diaphragm having a lenticular shape, 20. The diaphragm is manufactured by casting an elastomer, for example polydimethoxy siloxane (PDMS) in a master mould. The display surface is viewed from side A and when in an uncompressed state (as shown) the diaphragm appears silvery, as a result of the diffractive and reflective properties of the lenticular shape.

When a pressure is applied to the indicator diaphragm, it contacts the peaks of the display diaphragm from side B. As the pressure is increased, the display diaphragm compresses the lenticular shape, changing the diffractive and reflective properties of the indicator diaphragm. At a certain amount of compression, depending on the end use of the pressure indicator, the display surface becomes transparent revealing the image on the indicator diaphragm.

Figure 4b shows a display diaphragm comprising three layers of lenticular material, 20. By using a layered structure, the amount of reflected light, when the diaphragm is uncompressed, is increased.

Figure 4c shows an indicator diaphragm comprising lenticular material 20. In this example, the lenticular material is rolled up and inserted in a tube (the display diaphragm, not shown). The triangles may face inwardly or outwardly. In this case they face outwardly. One layer of the lenticular material may be used or, the indicator diaphragm may comprise a number of layers which can be made by creating a spiral of the indicator diaphragm prior to insertion into the tube. This example is particularly suitable for use in tyre valves.

Figure 5 shows a tapered tube of elastomeric material having a frosted outer surface, 21. The frosted surface is produced by grit blasting the surface of mould in which the tube is formed. The tube is placed between the display diaphragm, 22 and the indicator diaphragm, 23. When compressed, the tube becomes transparent. As the 5 tube is tapered, the end of the tube having the largest diameter is compressed first so, the whole indicator diaphragm is revealed only when the whole tube is compressed i.e. when the applied pressure is sufficient to compress the end of the tube having the smallest diameter. This example is useful when there are upper and lower limits of acceptable pressure within a body in fluid communication with the 10 indicator diaphragm.

Figure 6 shows that the tapered tube of Figure 5 may be substituted with a tapered triangular elastomeric tube 24. Small sections of the tube may be removed providing a space between sections of the indicator diaphragm. This could be used to provide a clearer indication of the transition between for example too low a pressure and a 15 pressure within acceptable limits.

Figure 7 shows an indicator diaphragm, 25 having projections, 26 of an elastomeric material. The projections are of graduated height. As the applied pressure to the indicator diaphragm is increased, 27 the projections press in turn against the display diaphragm, 28 producing first one dot and then a series of dots.

20 Figure 8 shows a means for amplifying the pressure applied to the indicator diaphragm. A display diaphragm, 30 has a transparent region within it, 31. The indicator diaphragm, 32 is housed within a rigid plastic cup, 33 which is sealed to the display diaphragm and impermeable. Within the cup is a first circular surface, 34 in communication with a second larger circular surface, 35 via a rod, 36 which passes 25 through the cup. The application of pressure to the second surface forces it down towards the cup. The force acting on the second surface is transmitted by the rod to the first surface and amplified by virtue of the different cross sectional or surface areas of the two surfaces. The amplification of the pressure depends on the ratio between the surface area of the two surfaces. The first surface will, at a 30 predetermined pressure, contact the indicator diaphragm which becomes observable through the display diaphragm. A biasing means, 37 which in this case is an elastomeric foam block but, may be a spring, is placed between the second surface

and the cup. When the applied pressure is removed, this foam forces the second surface back to its starting position.

**CLAIMS**

1. A pressure indicator comprising  
a display diaphragm, and  
an indicator diaphragm coupled to and in fluid communication with the display  
diaphragm and forming a compartment with the display diaphragm,  
wherein, in use, a change in pressure applied to the indicator causes relative  
movement between the diaphragms which is observable either on the outer surface of  
the display diaphragm or through the display diaphragm.
2. A pressure indicator as claimed in claim 1 further comprising a means to amplify the  
relative movement between the diaphragms which results from the change in pressure.
3. A pressure indicator as claimed in claim 2 wherein the means to amplify the change in  
pressure comprises  
  
an article having a first surface and a second surface, the second surface having a larger  
cross sectional area than the first surface;  
  
wherein the first surface is in fluid communication with one of the diaphragms and in use,  
a change in pressure applied to the second surface causes an amplified movement of  
the first surface.
4. A pressure indicator as claimed in claim 3 wherein the first surface comprises the  
indicator diaphragm.
5. A pressure indicator as claimed in any of claims 2 to 4 wherein the second surface is  
biased against the rigid structure.
6. A pressure indicator as claimed in claim 5 wherein the biasing means comprises a  
spring or elastomeric material.
7. A pressure indicator as claimed in any preceding claim wherein the display diaphragm is  
transparent.

8. A pressure indicator as claimed in claim 1 wherein the compartment contains a liquid or gel.
9. A pressure indicator as claimed in claim 8 wherein the liquid or gel is partially or fully opaque.
10. A pressure indicator as claimed in any preceding claim wherein the indicator diaphragm bears a recognisable configuration or pattern.
11. A pressure indicator as claimed in claim 10 wherein the recognisable configuration or pattern comprises a symbol or graphic projecting from the surface of the indicator diaphragm towards the display diaphragm.
12. A pressure indicator as claimed in claim 10 or claim 11 wherein the configuration or pattern comprises at least two components, each component contacting the display diaphragm at different pressures.
13. A pressure indicator as claimed in claim 12 wherein the at least two components have different colours.
14. A pressure indicator as claimed in claim 12 or claim 13 wherein the at least two components have different visibility.
15. A pressure indicator as claimed in any preceding claim wherein either the display diaphragm or the indicator diaphragm comprises a flexible polymer.
16. An apparatus comprising a fluid reservoir and a pressure indicator according to any preceding claim wherein one of the diaphragms is in fluid communication with the fluid reservoir.
17. An apparatus according to claim 16 wherein the apparatus is an inflatable.
18. A method of indicating fluidic or mechanical pressure using a pressure indicator according to any of the preceding claims.
19. A ball comprising a pressure indicator as claimed in any preceding claim.

Fig.1.

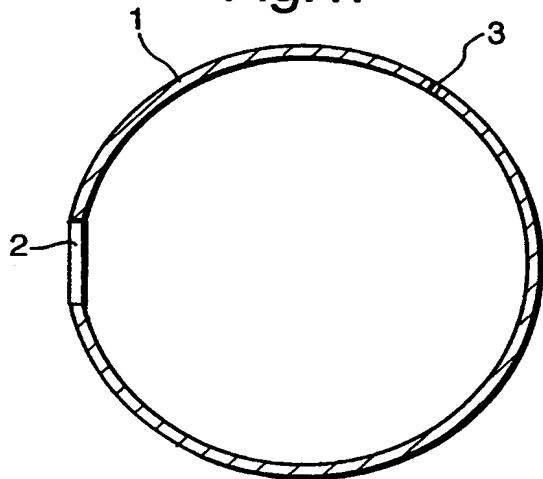
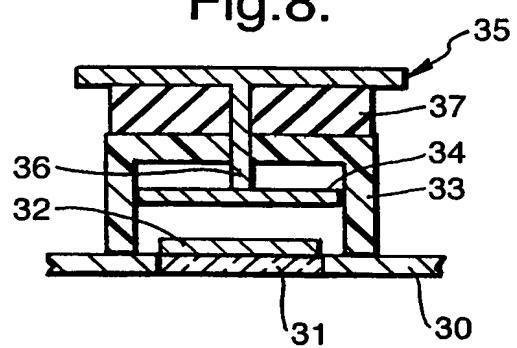
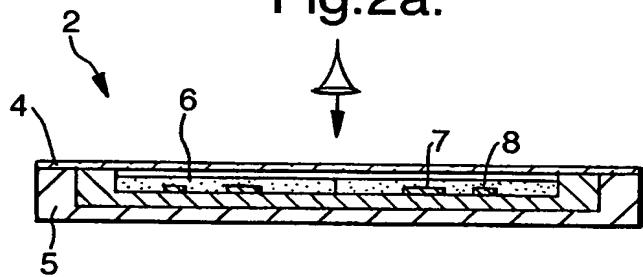
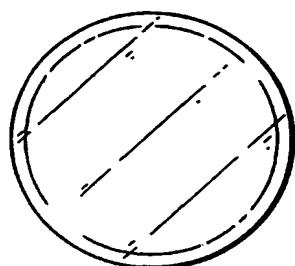
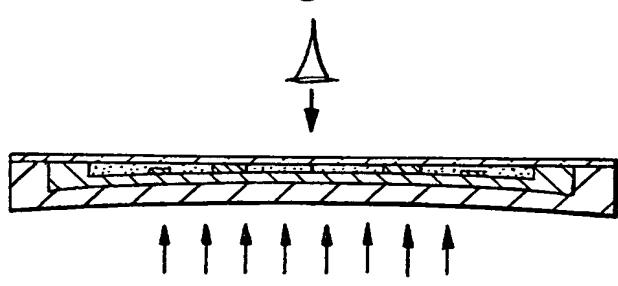
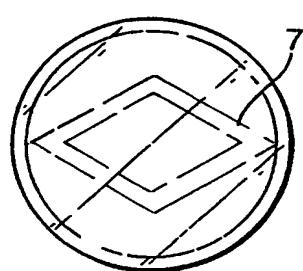
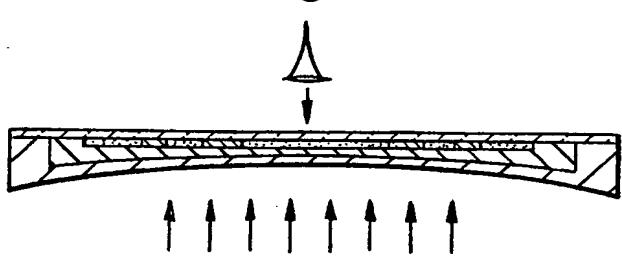
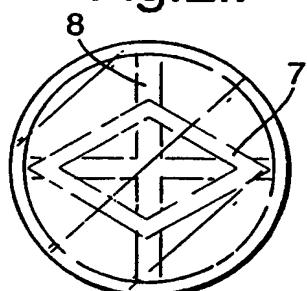


Fig.8.



**Fig.2a.****Fig.2b.****Fig.2c.****Fig.2d.****Fig.2e.****Fig.2f.**

3/5

Fig.3a.

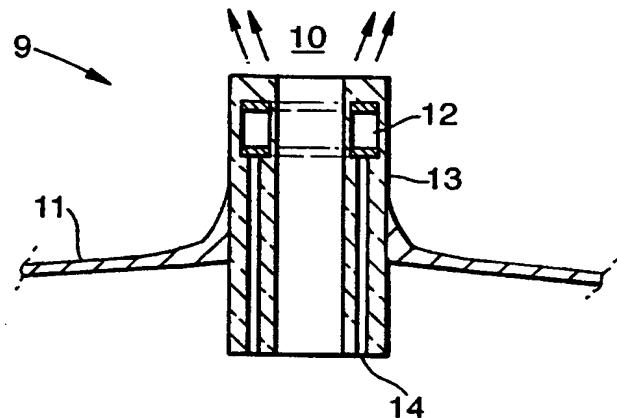


Fig.3b.

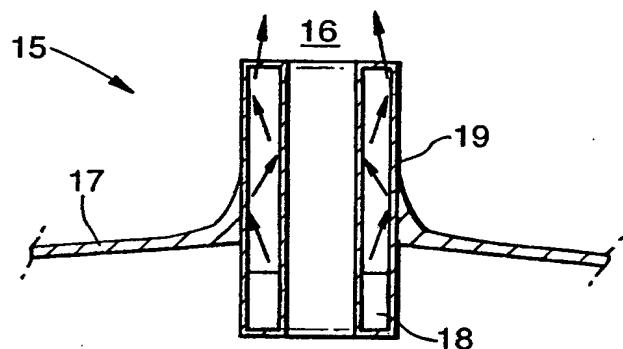
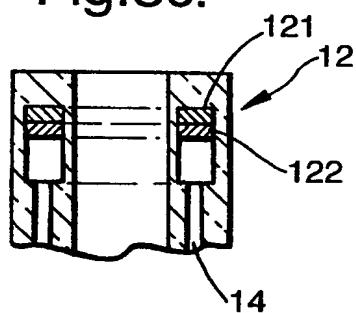


Fig.3c.



SUBSTITUTE SHEET (RULE 26)

Fig.4a.

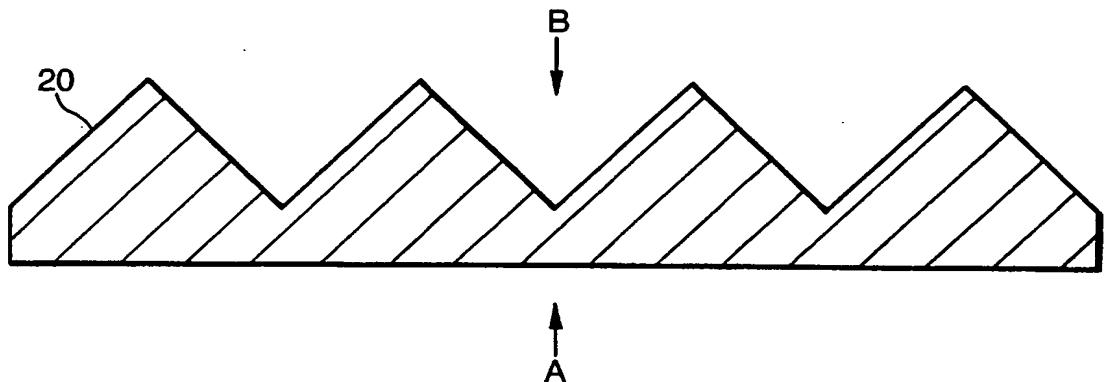


Fig.4b.

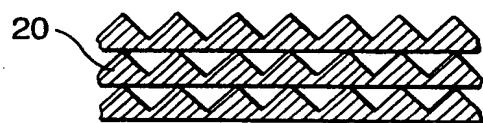
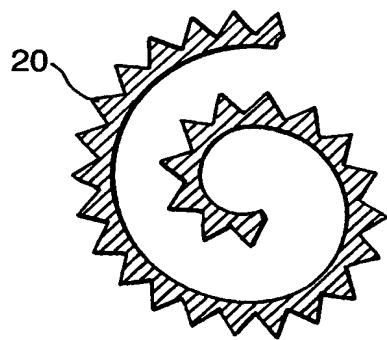


Fig.4c.



5/5

Fig.5.

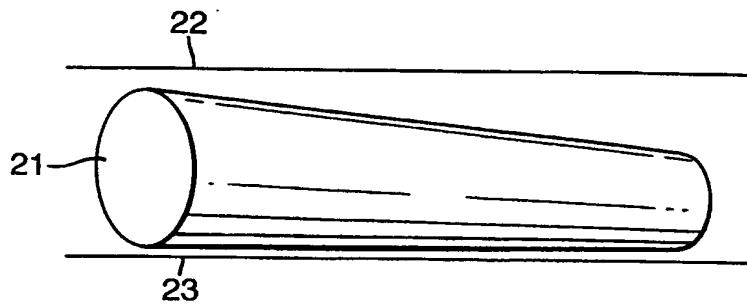


Fig.6.

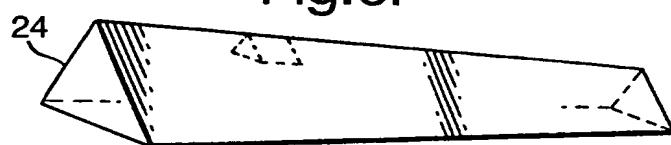
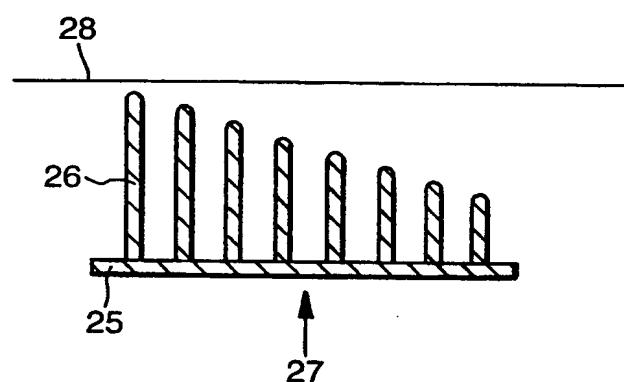


Fig.7.



SUBSTITUTE SHEET (RULE 26)

## INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/03072

<b>A. CLASSIFICATION OF SUBJECT MATTER</b>		
IPC 7 G01L19/08 G01L19/12 G01L17/00 G01L7/08		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b>		
Minimum documentation searched (classification system followed by classification symbols) IPC 7 G01L A63F A63B		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practical, search terms used) EPO-Internal, WPI Data, PAJ		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 189 979 A (C.H. POPENOUE) 2 March 1993 (1993-03-02) the whole document	1-4, 7-9, 16, 18
X	GB 2 229 003 A (NITTO KOHKI CO LTD) 12 September 1990 (1990-09-12) page 10, line 2 -page 12, line 19; figures	1-9, 16, 18
X	US 3 703 879 A (C.K. HUTHSING, JR.) 28 November 1972 (1972-11-28) the whole document	1, 7-11, 15, 16, 18
X	DE 296 16 337 U (T.-T. HUANG) 7 November 1996 (1996-11-07) the whole document	1, 7, 10, 16-19
		-/-
<input checked="" type="checkbox"/>	Further documents are listed in the continuation of box C.	<input checked="" type="checkbox"/> Patent family members are listed in annex.
* Special categories of cited documents :		
*A* document defining the general state of the art which is not considered to be of particular relevance		
*E* earlier document but published on or after the international filing date		
*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)		
*O* document referring to an oral disclosure, use, exhibition or other means		
*P* document published prior to the international filing date but later than the priority date claimed		
*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention		
*X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone		
*Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art		
*D* document member of the same patent family		
Date of the actual completion of the international search	Date of mailing of the international search report	
31 October 2000	07/11/2000	
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentdaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl. Fax: (+31-70) 340-3016	Authorized officer  Van Assche, P	

## INTERNATIONAL SEARCH REPORT

International Application No
PCT/GB 00/03072

## C(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	GB 2 069 139 A (HISANORI WARIHASHI) 19 August 1981 (1981-08-19)  page 2, line 41 - line 65; figures _____	1,7, 10-12, 15-18
X	US 2 938 379 A (C.K. REH) 31 May 1960 (1960-05-31) the whole document _____	1,7-9, 16-18
A	US 2 536 321 A (A.J. SMITH ET AL.) 2 January 1951 (1951-01-02) column 4, line 23 - line 33; figures _____	1
A	US 2 325 490 A (H.O. ELFTMAN) 27 July 1943 (1943-07-27) the whole document _____	18
A	EP 0 001 120 A (AMERACE CORPORATION) 21 March 1979 (1979-03-21) abstract; figures _____	1,12

**INTERNATIONAL SEARCH REPORT**

Information on patent family members

Informed	Application No
	PCT/GB 00/03072

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
US 5189979	A	02-03-1993	NONE		
GB 2229003	A	12-09-1990	JP 1930919 C		12-05-1995
			JP 2236430 A		19-09-1990
			JP 6060859 B		10-08-1994
			DE 4007388 A		13-09-1990
			KR 9305165 B		16-06-1993
			US 5014786 A		14-05-1991
US 3703879	A	28-11-1972	NONE		
DE 29616337	U	07-11-1996	US 5677492 A		14-10-1997
GB 2069139	A	19-08-1981	DE 3104081 A		24-12-1981
			FR 2475726 A		14-08-1981
			US 4366708 A		04-01-1983
US 2938379	A	31-05-1960	NONE		
US 2536321	A		NONE		
US 2325490	A	27-07-1943	NONE		
EP 1120	A	21-03-1979	US 4166429 A		04-09-1979
			US 4166430 A		04-09-1979
			BE 22 T		11-01-1980
			DE 2857183 A		21-02-1980
			FR 2434380 A		21-03-1980
			GB 2041527 A		10-09-1980
			NL 7815019 A		31-10-1979
			NL 7815019 T		31-10-1979
			CA 1110085 A		06-10-1981